

Massive Rigid Body Dynamics

CS171.1 Final Project

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Outline

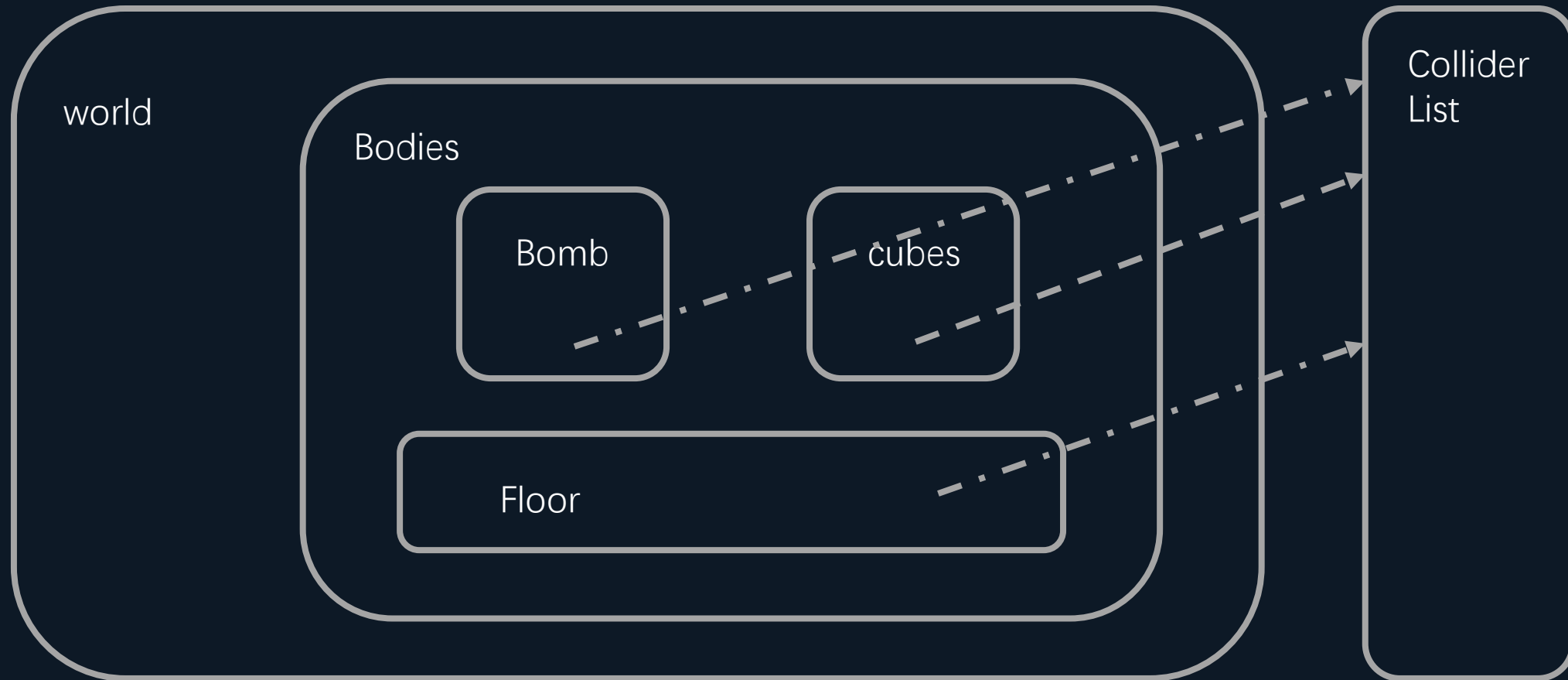
- Introduction
- Implementation Details
- Demo
- Q&A

Introduction

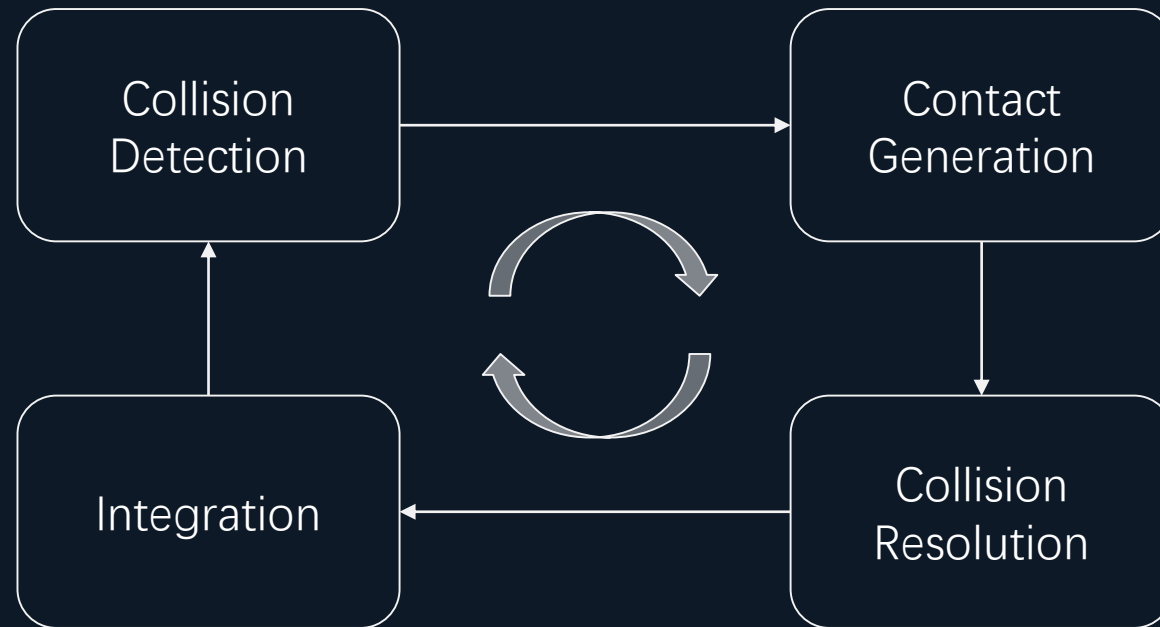
Rigid body physics used in game engine



World Generation



Implementation Details



Fundamental

Linear Velocity

$$x(t + \Delta t) = x(t) + V(t)\Delta t$$

Angular Velocity

$$O(t + \Delta t) = O(t) + w(t)\Delta t$$

$$O(t + \Delta t) = R(\hat{w}(t), |w(t)| \Delta t)O(t)$$

Torque

$$\tau(t) = r(t) \times F(t)$$

Moment of Inertia

$$I_{\hat{n}} = \hat{n}^T I \hat{n}$$

Linear Momentum

$$P(t) = mv(t)$$

Angular Momentum

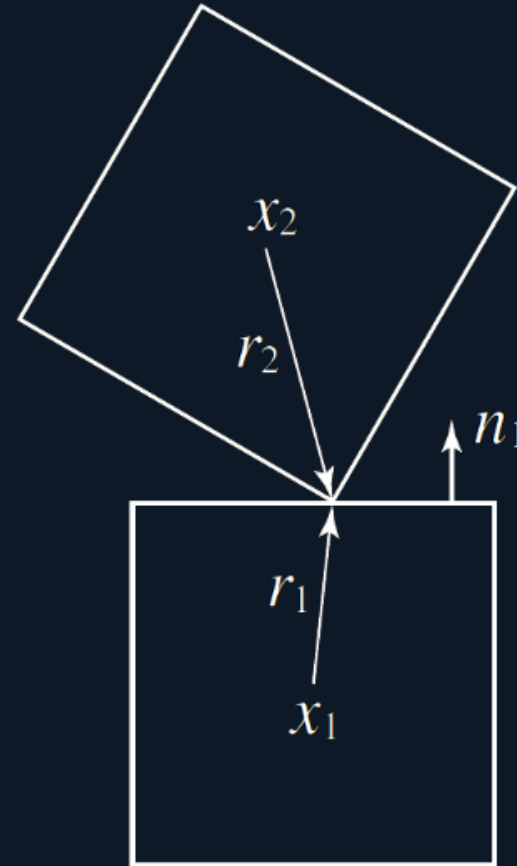
$$I(t) = Iw(t)$$

Constrains

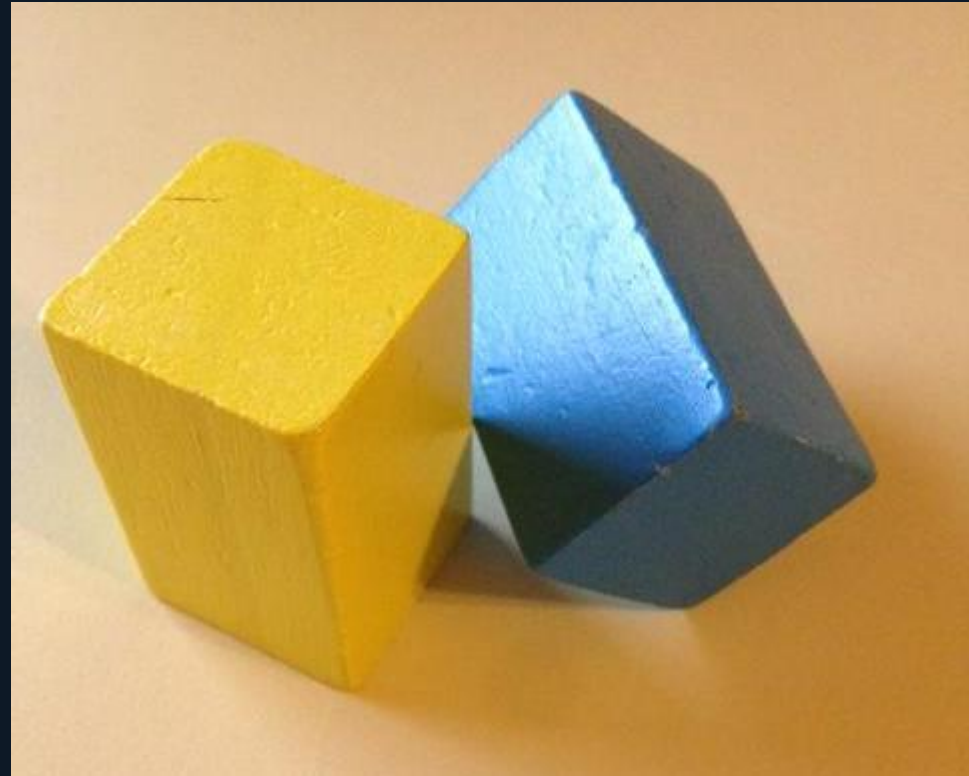
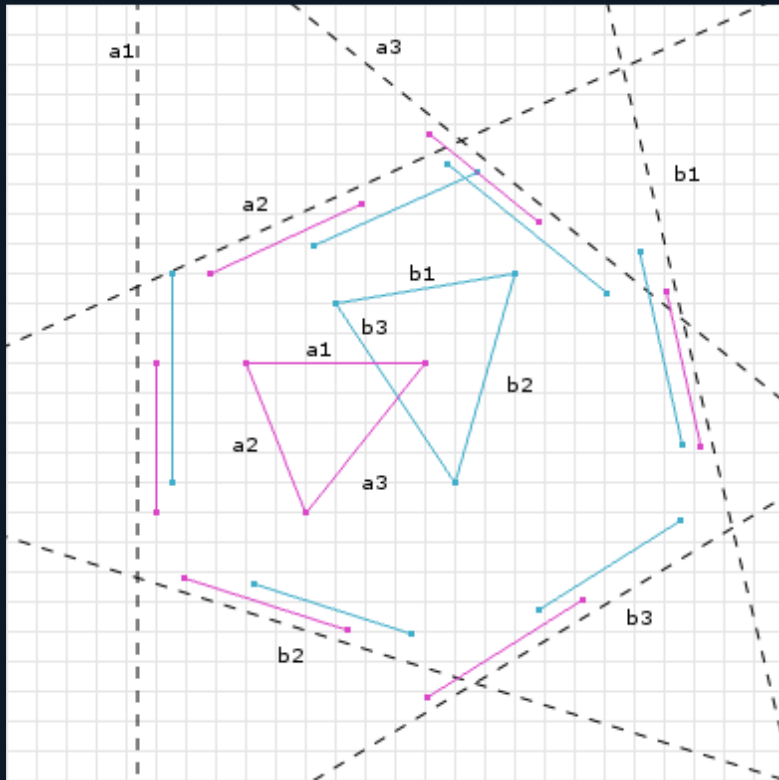
$$C_n = (x_2 + r_2 - x_1 - r_1) \cdot n_1$$

$$\dot{C}_n = (v_2 + \omega_2 \times r_2 - v_1 - \omega_1 \times r_1) \cdot n_1 + (x_2 + r_2 - x_1 - r_1) \cdot \omega_1 \times n_1$$

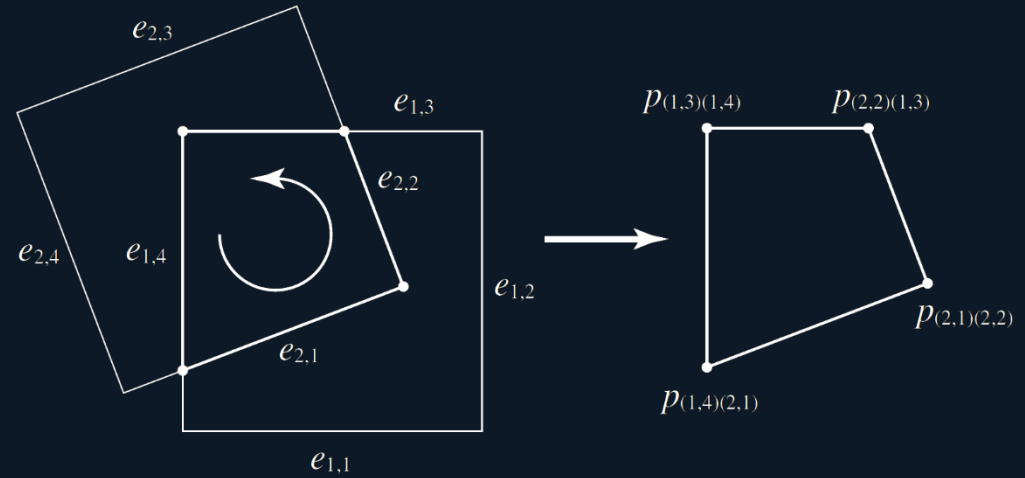
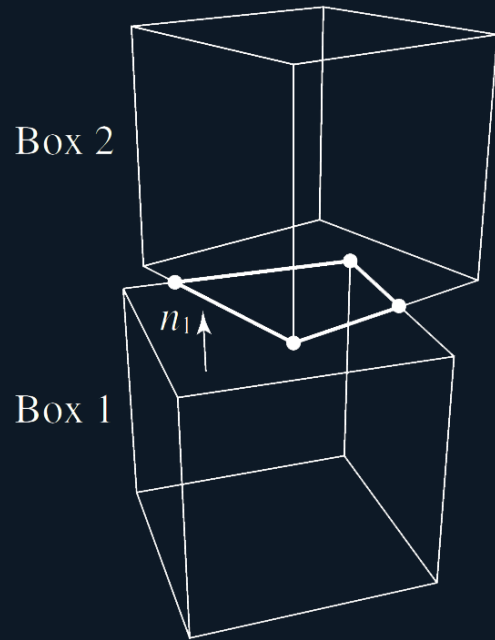
$$J_n V = \begin{pmatrix} -n^T & -(r_1 \times n)^T & n^T & (r_2 \times n)^T \end{pmatrix} \begin{pmatrix} v_1 \\ \omega_1 \\ v_2 \\ \omega_2 \end{pmatrix}$$



Collision Detection



Contact Generation



Integration

Linear Velocity

$$x(t + \Delta t) = x(t) + V(t)\Delta t$$

Angular Velocity

$$O(t + \Delta t) = O(t) + w(t)\Delta t$$

$$O(t + \Delta t) = R(\hat{w}(t), |w(t)| \Delta t)O(t)$$

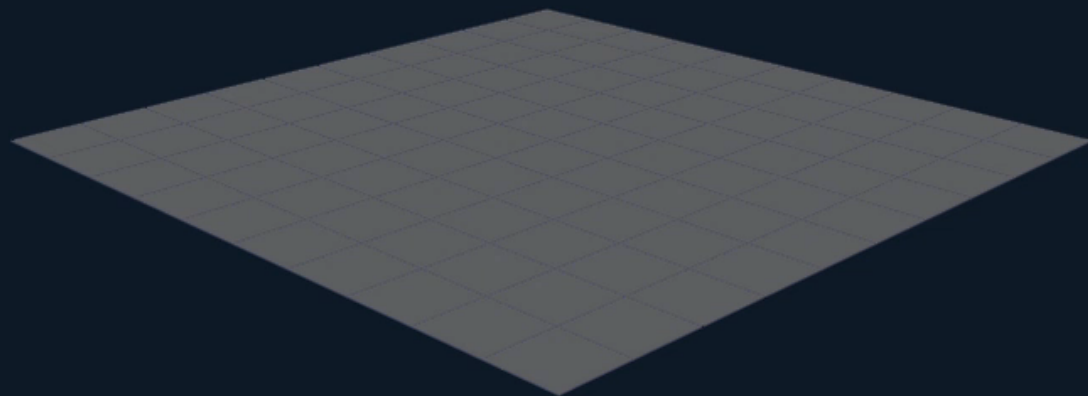
Linear Impulse

$$\Delta P = F(t)\Delta t$$

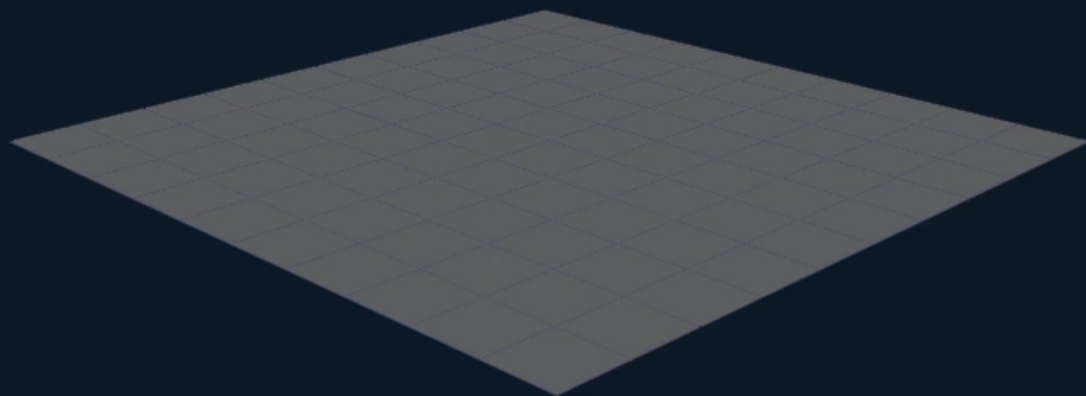
Angular Impulse

$$\Delta L = \tau(t)\Delta t$$

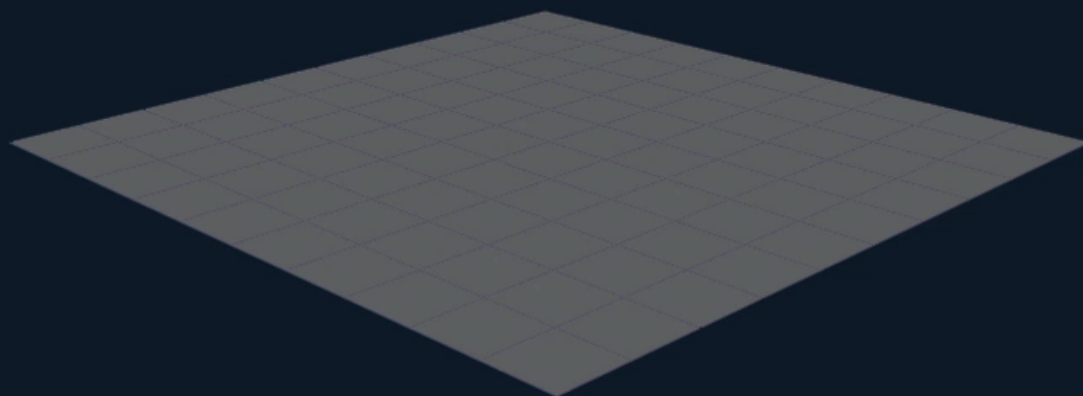
DEMO



collision



Easter Egg



Q&A